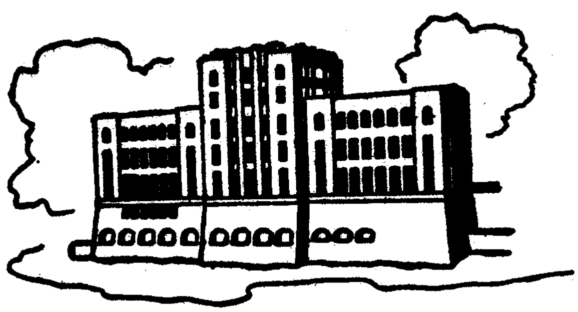
#185

QUANTIFICATION OF RECREATIONAL USE OF THE CORALVILLE RESERVOIR

by

Thomas E. Croley II
Rosa Chen

Sponsored by
Office of Water Research and Technology
Iowa State Water Resources Research Institute
(Title I Annual Allotment Project No. A-054-IA)



IIHR Report No. 185

Iowa Institute of Hydraulic Research
The University of Iowa
Iowa City, Iowa

March, 1976

QUANTIFICATION OF RECREATIONAL USE

OF

THE CORALVILLE RESERVOIR

by

Thomas E. Croley II
Rosa Chen

Sponsored by

Office of Water Research and Technology
Iowa State Water Resources Research Institute
(Title I Annual Allotment Project No. A-054-IA)

IIHR Report No. 185

Iowa Institute of Hydraulic Research
The University of Iowa
Iowa City, Iowa

March, 1976

PREFACE

This study was performed to construct a value function representing recreational use of the Coralville reservoir near Iowa City, Iowa under research entitled: "Flood Control Management in Sedimenting Reservoirs Subject to Recreation Demands". A companion study, just completed, attempted the same for flood control values downstream of the reservoir. These value functions are being used in an objective trade-off and optimization study to determine best operation plans for each level of trade-off between the operation objectives of flood control and recreation. The value function developments were plagued with a paucity of data and hence, conventional rigorous estimation of mathematical relations were impracticable. The developments made the maximum use of available data, physical insights, and intuitive reasoning. Its also important to emphasize that results represent an estimate of recreational value as affected mainly by reservoir operations; they do not represent estimates of recreational demand or projections of recreational demand.

ABSTRACT

An estimate of recreational use, as affected by reservoir operation decisions on the Coralville reservoir near Iowa City, Iowa, is desired for subsequent use in objective trade-off studies. Therefore, a quantitative measure was derived from available data, which is applicable for determining reservoir operation effects on an index of recreational use for the Coralville reservoir. This measure relates recreational use, expressed in visitor-days to the reservoir, to pool area, weather, seasonal variation, and population of surrounding areas. It is not to be interpreted as a forecast of recreational demand; it is intended primarily to serve as an indicator of operation effects on recreational use.

ACKNOWLEDGMENTS

The writers appreciate the constructive review given the study and its report by Prof. Kenneth Dueker and Graduate Student Fred Joyal of the Institute of Urban and Regional Research, University of Iowa, Iowa City, Iowa. This work was supported in part through the Title-I Annual Allotment Program, project number A-054-IA of the Iowa State Water Resources and Research Institute under Annual Allotment Agreement no. 14-34-0001-6016 with the United States Department of the Interior, Office of Water Research and Technology.

TABLE OF CONTENTS

LIST OF FIGURES

QUANTIFICATION OF RECREATIONAL USE OF THE CORALVILLE RESERVOIR

I. INTRODUCTION

During the past few decades, many agencies have built storage reservoirs for various purposes including flood control, irrigation, power and water supply, etc. These activities gave rise to water-based recreational use such as fishing, boating, and swimming, which have increased steadily and rapidly over the years. Such uses prompted the recognition of recreation as one of the important objectives to be considered by planners in the planning and management of reservoir projects. Research on recreational demand, supply, and management have increased as water-based recreation has become an increasingly important desire of the population.

The task of supplying present and future generations with appropriate recreational facilities is nowhere near complete. In order to provide people with recreational opportunities commensurate with the needs of other uses of multipurpose projects, researchers need to know more about the nature of recreational demands, uses, and benefits derived from recreational developments. The major objectives of this report are: to improve the understanding of the nature of recreational effects of water development projects, to review the methods for quantitative estimation of recreational values, and to provide a basis for estimating operation-related recreational values for a multipurpose reservoir. The recreational values will be limited to those which can be related to quantifiable parameters of reservoir operation management. This is necessary since subsequent use of the recreational value function is to be made in an operation study where trade-offs between flood control and recreation are investigated.

Previous research on recreation in Iowa indicates that the recreational use of a limited supply of water bodies is increasing in importance (Gardner and Hultquist, 1973). The Coralville reservoir area near Iowa City is considered herein. This man-made reservoir, planned primarily as a flood control measure in 1930, went into operation in 1958. Over the years, there has been an awareness on the part of the reservoir managers and the public, that the recreational utility of the reservoir has risen in response to public demand. The large body of water behind the Coralville dam forms one of the most significant recreational areas in the state. The major recreational activities of this area are swimming, fishing, boating, picnicing, sailing, water skiing, hunting, and camping around the area (Gardner and Hultquist, 1973). Potential conflicts in the reservoir area between flood control and recreational use are not uncommon and warrant detailed investigations into all aspects of the purposes. This report examines recreation, and a companion report examines flood control values.

II. DEFINITION OF RECREATION

"Recreation", as used in this study, affords an outlet for self-expression, for release of tensions, and for the attainment of satisfaction in life through relaxation. It may take the form of looking at interesting scenery, participating in a family picnic, hunting, camping, fishing, boating, skiing, etc. The various kinds of recreation may or may not compete with each other, depending upon the physical situation and the extent of uses. However, outdoor recreation is a practical category, not a theoretical concept.

The natural resources for recreation are land, water, or other natural features actually used for recreation. During the past few decades, the country's social, economic, and political aspects have changed rapidly. An increasing population, a rising real income per capita, more leisure time, shortening of the work days, general use of automobiles, and better highways have affected the life of the people and have enlarged the importance of recreation. The demand for outdoor recreation is very strong and clearly demonstrable. If the physical opportunity for outdoor recreation exists, and if people are free to choose how to spend their money and time, a large majority of them will spend some on outdoor recreation. The recreational area can be developed with good roads, sewage facilities, picnic tables, and other man-made improvements such as development of water areas for boating and for swimming. Interest here is in how water area changes affect recreational uses, from an operational point of view.

The factors that led to increased recreational uses in the past may continue to some extent in the future. Although some factor increases are uncertain, it is apparent that recreational use will continue at high levels. Therefore, recognizing the importance of recreational value in reservoir operation is meaningful. The Tennessee Valley Authority (TVA) was the first organization to support the concept that recreation is a real and valuable objective of reservoir construction and operation. It encourages the recreational use of reservoirs and adjoining land.

III. DEMAND AND USE

People who are likely to visit public outdoor recreation areas may weigh the costs of so doing against alternatives at the same cost. Their recreational behavior is a free and personal choice. It may be simply said that people demand recreation. "Demand" used in outdoor recreation is a word with several meanings. As applied by economists, it means a schedule of prices (costs of the recreation experience) and associated levels of use for a specific area or facility. Usually, the term "recreation demand" is used for quantities that are not really demands, but are recreational uses. These two terms are often used synonymously. In general, recreational demand refers to the units or quantity desired at the prevailing recreational opportunity conditions; recreational use, which depends both on existing demand and the availability of supply, refers to gross attendance at the facilities. The number of visits in a given year is not the demand for these facilities in that year, but rather it is the use made of the facilities. In this study, recreational use is defined as the amount of attendance at a recreational area, at a specific level of recreational supply and price. Accurate information on recreational use is desirable to enable management of the recreation facility to meet recreation needs.

Outdoor recreation is changing, the future may be quite different from the past, and little is known, quantitatively, about the past. No methodology can yield completely satisfactory answers to questions of recreational needs in the absence of adequate data. In view of these circumstances, one must be aware of the inherent data limitations which any study of recreational use possesses.

IV. MANAGEMENT OF WATER-BASED RECREATION

It is apparent that water is an important drawing factor of many recreational areas. The investigation conducted by Gardner and Hultquist in 1973 revealed that over three-fourths of those interviewed indicated that they would not be in the Coralville-Macbride recreational area if it were not for the water. The Gardner and Hultquist studies also indicated that the significance of water is very strong in swimming, fishing, boating, and other recreations. These are dependent upon both the provision of facilities and the mangement of facilities. Mangement includes sewage facilities, parking lots, water level fluctuation, law enforcement, and advertisement. This study is directed at water level management for the Coralville reservoir. It appears that water levels in reservoirs directly influence public response. This is evidenced clearly by records of public meetings and news clippings concerning the Coralville area. High water levels provide deep water and long reaches for boaters and easier access for some fishing and hunting, while fluctuations can improve game hunting or destroy it. Other recreation interests depend heavily on the management of the water level.

The essence of multiple-use management of water resources is judicious planning and choosing among competing uses so as to minimize conflicts and maximize total output. To do so requires knowledge of the overall influence of any operation management plan on all relevant interests. Having ascertained the influence of reservoir operations on recreational value, decisions based on objective trade-offs can be made.

V. MEASUREMENT OF RECREATIONAL USE

In choosing to use recreational facilities, people behave in a way that it is not fundamentally different from the way they purchase other items. In general, recreational use may be measured in many ways, three of which appear most suitable for the study reported herein:

1) the number of visits, entrances, or admissions to an area,
2) the number of visitor-days, reflecting the number of days of individual usage, or
3) the number of visitors or individuals who use the area.

In each of these ways, emphasis is placed on quantity; it is presumed that recreational quality is also revealed in these numbers, up to a point. Below a limiting value of recreational use, large usuage numbers reflect better quality facility conditions. Above the limit, quality decreases due to crowding and loss of facility use by some. In this study, the "number of visitor-days" is used to estimate recreational benefit of the water area. This, of course, "glosses over" many aspects of recreational benefit which are expressed in different manners. However, this index should at least give a general indication of recreational benefits. It should be noted that recreational use of a water area tends to sharply fluctuate seasonally. Recreation activity also tends to be heaviest on weekends and holidays. Recreational value must, therefore, be a function of time.

VI. MODELING RECREATIONAL USE

As previously described, water resource planning and management must take into account the recreational use no matter how difficult and imperfect the forecast may be. The factors which affect recreational use are many and complex. Development of a model to estimate recreational use should include searching for relevant factors that affect recreational behavior, and building the relationship between these factors. In general, most mathematical models relate the number of visits, or visitor-days, or user-days, per unit time to a set of major causal factors affecting recreational use such as supply availability and accessibility and characteristics of population, time, and weather.

The basic assumption of these mathematical forms is that the causal factors will exist in a more or less extrapolated fashion in the future. In general, the approaches to estimate recreational use can be classified into three major categories: the systems approach, the local, regional or national approach, and the specific resources approach.

A. The Systems Approach. The systems approach is a procedure for constructing a system analog. This approach can be applied to a site, a complex, or a region. It is used to estimate recreational use within and among recreational resources. Ellis (1966) and Cesario (1969) were two successors of applying the systems model for recreational systems. They treated the recreational system as an electric-circuit analog. The origins (population centers) act like sources of current (potential use). The current infiltrates into the system in paths of least resistance until it reaches the destinations (recreational areas). This is a good conceptual method, but still has some defects. As Cesario (1969) described: "... In general, it suffers the same problems of other methods in that the variables have to be measured and each component modeled before the analysis can proceed. In addition, the assumption of a linear system is restrictive."

B. The Local, Regional, or National Approach.

1. Simple Trend Extensions. If the recreation area has relatively stable factors which affect recreational use and the management system, the extension of past and current trends is useful for estimating recreational use. Since it is a simple method to apply, and since it provides some degree of accuracy for the short term, this method has been widely used.

2. Trend Extensions in Basic Causal Factors. Since the extension of past trends sometimes produces diverse estimates or is noncredible for long-run projections, there exists an obvious need for taking into consideration the past trends in the causal factors. These are factors which have accompanied past growth in recreational use and which have contributed to it, e.g. increases in leisure time, population growth, etc. The optimistic assumptions of this method are: 1) the factors which underlie current recreational behavior are known, and 2) the relationship between the selected causal factors and recreational use will not change in the future.

3. Projection of User Characteristics. Characteristics of the people who currently participate in recreational activity is the most important factor which affects the recreational use of a particular recreational activity. This approach projects the user characteristics to some desired future year, and then estimates the probable future participation. According to different assumptions of future recreational use, selected components of the predictive model can be changed to estimate future use. It is a dynamic and flexible approach; it is more meaningful to take into consideration the changes in recreational supply characteristics

which can be incorporated into such a model. Many different models using different factors have been developed. But the functional form of regression remains the same. For example, Cicchetti et al (1969) developed the model for recreational use as follows:

$$V_{it} = f(D_{t-1}) + g(Q_{t-1}) + h(S_t) \quad (1)$$

where V_{it} = expected quantity of a particular type of outdoor recreation used by the ith population center in current time period t; D_{t-1} = the distance between the ith population center and the recreational area in period t-1; Q_{t-1} = measure of relative availability of recreational areas in period t-1 such as index of crowding, water availability and acreage of recreational area available; and S_t = socio-economic characteristics of the ith population center in time period t.

C. The Specific Resource Approach. The models that forecast recreational use for specific recreational facilities can be classified into three approaches: resource capacity models, gravity models and supply characteristics models.

1. Resource Capacity Models. The basic assumptions of this approach are that the recreational resources are limited, the recreational demand is effectively infinite, and the increasing recreational use can only be met by resource development up to a certain point. In view of these assumptions, forecasts of recreational use are simply not needed. After the maximum is reached, the excessive number of users will result in degradation of the resources. When this occurs, equitable management control systems should be instituted to allocate use in order to maintain the

basic resource integrity.

2. Gravity Models. The gravity model is essentially a formula with component parameters built in; its form is similar, while not fully analogous, to the formula for gravitational attraction between masses. It is an attempt to build up a mathematical relationship between the frequency of visits to a recreational area and the distance from population center to the recreational area. It has been widely used (Hotelling, 1947; Trice and Wood, 1958; Clawson, 1959; Ellis, 1966; Cesario, 1969). The basic form of the model (Cesario, 1969) is

$$V_{ij} = N_i \left[\frac{\frac{A_j}{D_{ij}^{\alpha}}}{\sum_{m=1}^{M} \frac{A_m}{D_{im}^{\alpha}}} \right] = N_i \; W_{ij} \; ;$$

$$W_{ij} \geq 0 \quad \forall \; i, j \text{ and } \sum_{j=1}^{M} W_{ij} = 1 \qquad (2)$$

where V_{ij} = number of visitors from population center i to recreational area j per unit time; N_i = total number of recreation trips per unit time from population center i; A_j = attractiveness of recreational area j; D_{ij} = distance or travel time from population center i to recreational area j; α = elasticity of visits with respect to distance; and W_{ij} = conditional probability that recreational area j will be chosen. The model is usually calibrated by trial-and-error procedures. Since many factors that effect recreational use are not included in this model and the computations are not simple, it is not suitable for use in management determination applications.

3. Supply Characteristics Models. This approach for estimating

future recreational use is based on the relationship among past use intensity, past supply, and physical characteristics of the recreational area. The general supply approach takes the form of a regression model. Knetsch (1964) developed the following equation relating the visit rate per thousand population, V_i in the ith zone of origin and the dollar cost of travel, C_i from zone i:

$$\log(V_i + 0.8) = 3.82462 - 2.39287 \log C_i \tag{3}$$

Regression coefficients for the above equation were fitted by the method of least squares from data collected over the period of July 1, 1963 to June 30, 1964 for the John H. Kerr reservoir which is located on the Virginia-North Carolina border.

In addition to distance and population, Merewitz (1966) found population density to be a statistically significant predictor variable. Using data collected from the Niargua Arm facilities at the Lake of the Ozarks, Missouri, for the periods 1950-1954 and 1956, Merewitz derived the following equation:

$$V_i = \exp\,(2.4976 - 1.8945\,S_i + 0.045/S_i^3 + 0.0025\,P_i)PD_i^{0.7978} \tag{4}$$

where V_i = visits from population center i to the lake; S_i = air distance from population center i to the lake in hundreds of miles; P_i = population of population center i in thousands; and PD_i = population density per square mile of population center i.

In a Texas reservoir study, Grubb and Goodwin (1966) developed another logarithmic regression equation for estimating recreational use:

$$\ln(V_{ij} + 0.8) = 8.603 + 0.573 \ln P_i + 0.753 \ln Y_i - 1.186 \ln C_{ij} - 0.327 \ln A_i + 0.210 \ln S_j \quad (5)$$

where V_{ij} = number of people visiting reservoir j from county i during the season; P_i = population of county i; Y_i = average income in county i; C_{ij} = distance from county i to reservoir j; A_i = measure of competing water areas for residents of county i; and S_j = size of reservoir j. This equation was used to project future use.

Considering additional parameters, Shafer and Thompson (1968) introduced the following:

$$V = 3409 - 0.0183\ A + 0.1757\ C(IC^2) \quad (6)$$

where V = number of groups visiting an Adiron deck campground per year; A = total square feet of the land and water area at the campground swimming beach; C = total number of campsites in the campground; and I = total number of islands accessible by motor boat from the campground.

Considering the time-path and supply-oriented variables in estimating water responses to the introduction of a water recreation facility, Seneca (1968) developed the following equation:

$$V_t = \alpha + \beta \cdot T + \gamma \cdot AVP_t + \sigma \cdot APP_t + \varepsilon_t \quad (7)$$

where V_t = recreation visits per capita in time period t; T represents a time trend in usuage; AVP_t = value of ancillary facilities per capita in time period t; APP_t = available water acres per capita in time period t; and ε_t = an error term. By analyzing the annual aggregate data for all TVA lakes from 1947 through 1965, he found a significant relationship between use and quality as follows:

$$\log V_t = 18.330 + 0.4134 \log AVP_t + 4.9519 \log APP_{t-1} + 0.08577T \quad (8)$$

It is apparent that an increase in availability of facilities and water leads to an increase in usuage. The power coefficient on APP is almost twelve times that on AVP, indicating the relative greater importance of changes in the quantity of available water area per capita in comparison to the changes in facilities.

Cesario (1969) proposed a similar equation,

$$\ln V_{ij} = \ln a + b \ln P_i + c \ln E_i + d \ln D_{ij} + e \ln A_j + f \ln O_j \quad (9)$$

where V_{ij} = number of visitors from population center i to recreational site j; P_i = number of people residing in population center i, E_i = measure of socio-economic status of the residents of population center i; D_{ij} = distance or travel time from population center i to recreational site j; A_j = attractiveness of recreational site j; and O_j = measure of the competing opportunities of recreational site j.

Another multiplicative function for recreational use was introduced by Seneca and Cicchetti (1969). They studied a sample consisting of 154 outdoor recreational sites in the Appalachian Region and fit the following equation:

$$\log V_j = 0.1413 \log L_j + 0.2681 \log W_j + 0.6562 \log P_j + 0.7856\ SR_j + 1.0764\ F_j + 4.7910\ C \quad (10)$$

where V_j = total recreation visits at site j; L_j = available land area at site j in acres; W_j = available water area at site j in acres; P_j = number of parking places at site j; SR_j = a binary variable coded zero if swimming is not a ranked activity at site j and unity if it is; F_j = a binary variable coded zero if no fee is charged at site j and unity if any fee is charged; and C is a constant (unexplained in the article).

A model which included a distance variable, a population variable, a facilities variable, a fees variable, a quality of site variable, and a seasonal variable was developed by Holman and Bennet (1973). Analyzing data from the Fort Worth district, they found that the seasonal factor was most important in determining recreational use.

VII. RECREATIONAL USE OF THE CORALVILLE RESERVOIR

The Coralville dam impounds one of East Central Iowa's more important water use areas. The U.S. Army Corps of Engineers owns and operates the lake and controls about 33,685 acres of adjoining land. The conservation pool is the third largest water body in Iowa. As previously mentioned herein, the water area and related land developments provide extensive opportunities for water-oriented recreation such as boating, swimming, fishing, hunting, and water skiing. Also, facilities for picnicking and camping are located at several points around the lake and their uses are also influenced by the water availability. Figure 1 illustrates the location of 10 public areas around the lake.

A. Data Availability. Several survey studies have been made by the Corps to estimate participation in recreational activities in the Coralville Lake area. The available total attendance records for the lake are listed in Tables 1a and 1b in the Appendix. This appears to be the only quantitative data available for estimation of total recreational use of the reservoir. It is utilized in the following section.

Investigations conducted by Gardner and Hultquist in 1973

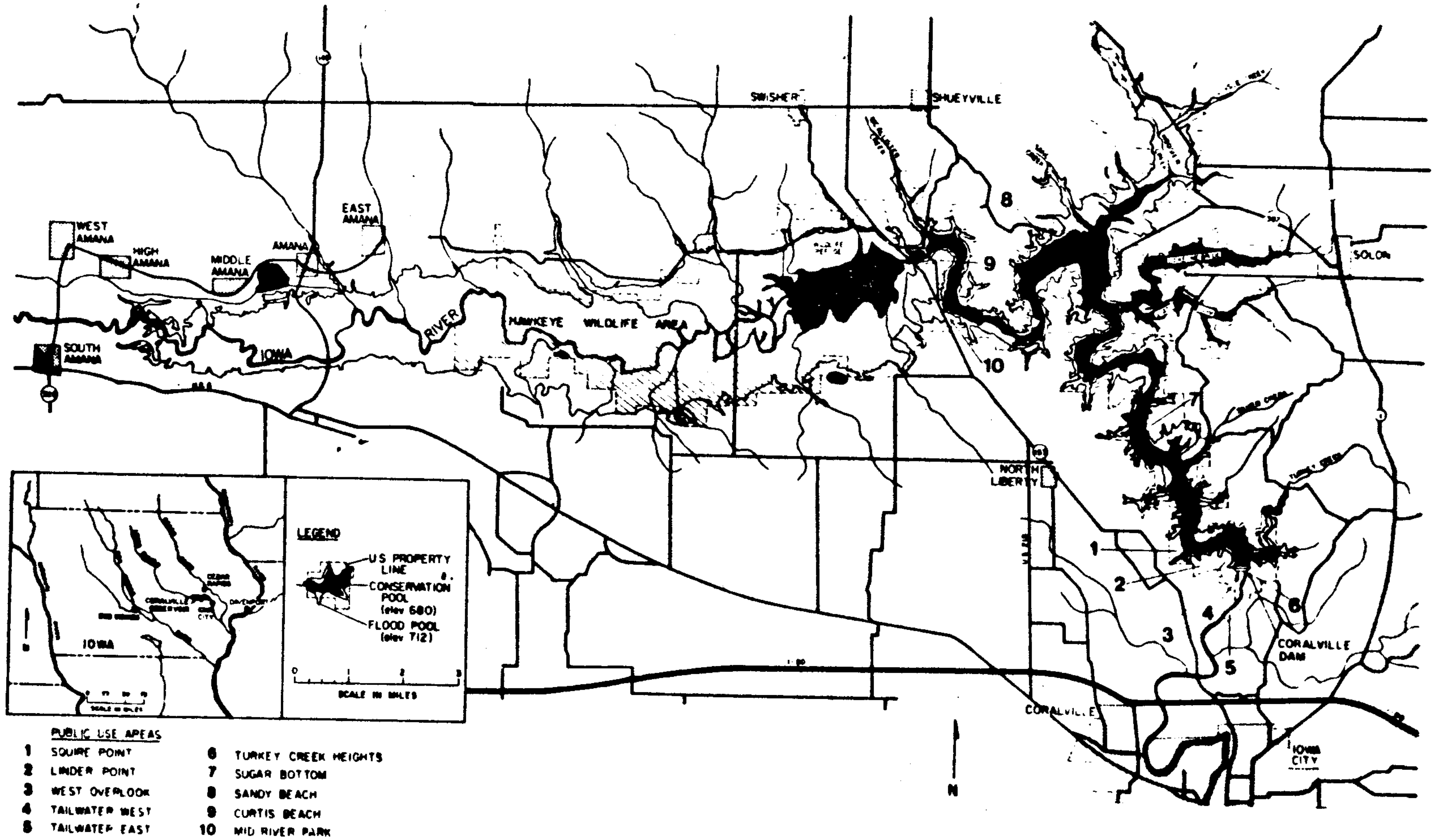


Figure 1 - Coralville Lake Public Use Areas

Source : U.S. Army Corps of Engineers, Draft Environmental Impact Statement for Coralville Lake and the Downstream area of Influence to Columbus Junction, Iowa, Rock Island, Illinois, 1975.

provide survey statistics on various user characteristics at the Coralville and MacBride lakes; they are included herein as Tables 2 through 8 in the Appendix. Several general observations may be made with regard to these data which will prove useful in model building. As indicated in Tables 2 and 3, most of the recreational users live within 5 hours of the reservoir (overall total is 97.0%) and a majority list "close vicinity" as a reason for coming (overall total is 35.4%). The majority of the people visiting the Coralville Lake reside in the two nearby urban areas of Iowa City and Cedar Rapids. Inspection of Tables 4, 5, 6, 7 and 8 reveals that the water acreage is an important attraction for many recreational users. It must be recognized that the Gardner and Hultquist survey is biased since no people were included in the survey who had left the area as a result of low pool levels. There is little known, therefore, of the impact on all users of pool fluctuations since largely only nearby users are included in the survey. Although various recreational opportunities are dependent on the biophysical properties of the water which change with the water level, much of the other recreational uses depend upon management of the water level from the point of view of aesthetics, access, water area, etc.

B. Model Building. Most studies of recreation endeavor to predict recreational demand relationships and derive recreational use for proposed project developments. An unique situation exists herein since the Coralville reservoir represents an existing project with known use characteristics (at least partially known). There exists now only a need to relate recreational use to the operation of the reservoir and other time-related factors such as weather, seasonal distribution of use, and growing population. There is no need to be concerned with recreational demand since this study is not concerned with development of facilities in anticipation of recreational demand relationships. This study is intended solely to relate the operations of existing facilities to the effects on the recreational uses of them.

In the following model development, weekly recreational use is modeled. The week as a basic time period is of interest so that resulting models will be consistent with existing optimization and routing models which will use the recreational value model. It also might seem more appropriate to construct two separate recreational use models: summer use and winter use. The nature of the recreational use, its causal factors, and hence the ensuing models can be argued to be significantly different for these periods of the year. Unfortunately, there is little data for winter months and what exists are largely estimations of use (not measurements). The lack of adequate data forces the use of a simplistic modeling approach based, where possible, on intuitive or physically based arguments. It does not appear feasible or reasonable to attempt construction of separate models with this data base. With the acquisition of future data, the separate model approach may prove tractable and practically worthwhile.

From the evidence presented in the last section, that the majority of recreational users live close to the site, it appears that the potential recreational use of the Coralville reservoir has increased largely in response to population growth of the area. Time-of-travel, distance, and related considerations are not as important for close-proximity areas and no major sudden changes in area income, economy, standard of living, etc. have occurred to the area population as a whole. Therefore, the effects of all these parameters are lumped herein into a single parameter in the recreational value function:

$$V \alpha a \qquad (11)$$

where V = number of visitor-days to the Coralville recreational area during a week; and a = a coefficient related largely to population growth in the surrounding area.

Again, from the evidence presented in the last section and from the recreation studies reviewed herein, it appears that the size of the Coralville pool surface is one of the main determinants of recreational use. This is due to the many size-related qualities of the water area (e.g., open space, water-land access, aesthetics, odor, boat travel lengths, various biophysical properties of the area, etc). There may also be a "lag effect" whereby size of the pool area in previous time period(s) has an effect on the use of the pool at a present time. This may be due to impressions of earlier experiences retained by users or to recommendations from other users. Both causal factors are based on conditions at earlier times in determining use at a present time. However, there is some question as to the magnitude of this "lag effect" when dealing with weekly time periods. Finally, there is no data (quantitative or qualitative) regarding the lag effect for the Coralville reservoir. Therefore, no effort at estimating this effect is made herein. In accordance with the other studies reviewed herein, a power relation is proposed, relating recreational value to the "attractiveness" of the site, expressed in terms of available pool surface area:

$$V \propto A^b \qquad (12)$$

where A = average weekly pool surface area of the Coralville reservoir in acres; and b = a power coefficient which is best estimated from data. Since there are no data on weekly visits to the Coralville area available, the value of b is selected herein based on consideration of other studies. Values of b range between 0.20 and 0.30 in the studies considered herein.

In particular, for annual variation (Seneca and Cicchetti, 1969) the least squares regression fit for b was 0.268. For seasonal variation (Grubb and Goodwin, 1966) the fit resulted in a coefficient of 0.210. It seems reasonable to expect that the marginal "attractiveness" of the site should be decreasing with respect to pool area. There is less unit appeal per acre (say) for larger areas because visitors become numerous and find the place less attractive. This saturation effect suggests a value of the exponent in equation 12 between 0 and 1, which results in an intuitively pleasing relationship as illustrated in Figure 2. Therefore, the value of b, for weekly variation in the water surface area of the Coralville pool, is set at b = 0.20 herein, consistent with all preceding observations. There is some question of the applicability of results from multi-site models with regard to a single-site model. Generally, the multi-site recreational use models are developed in a context of competing resources. Here, the single-site application recognizes no competing recreation alternatives since the objective of development is to assess reservoir operation related impacts on recreation use. The multi-site model coefficients may not then be strictly applicable. In lieu of data or more relevant studies, however, these studies are used to indicate general guidelines for parameter values as just discussed.

Although there is an obvious seasonal influence on recreational use for the Coralville reservoir, there again is available no weekly data for estimation of this effect. The monthly data from 1971 to 1974 can be utilized however. A weekly distribution was derived form the monthly distribution by assuming that visits were spread evenly over each week within the month, see Table 9 in the Appendix. Given perfect weather and ideal pool surface area, unchanged throughout the year, the visits to the reservoir are assumed to be distributed through the year as given in

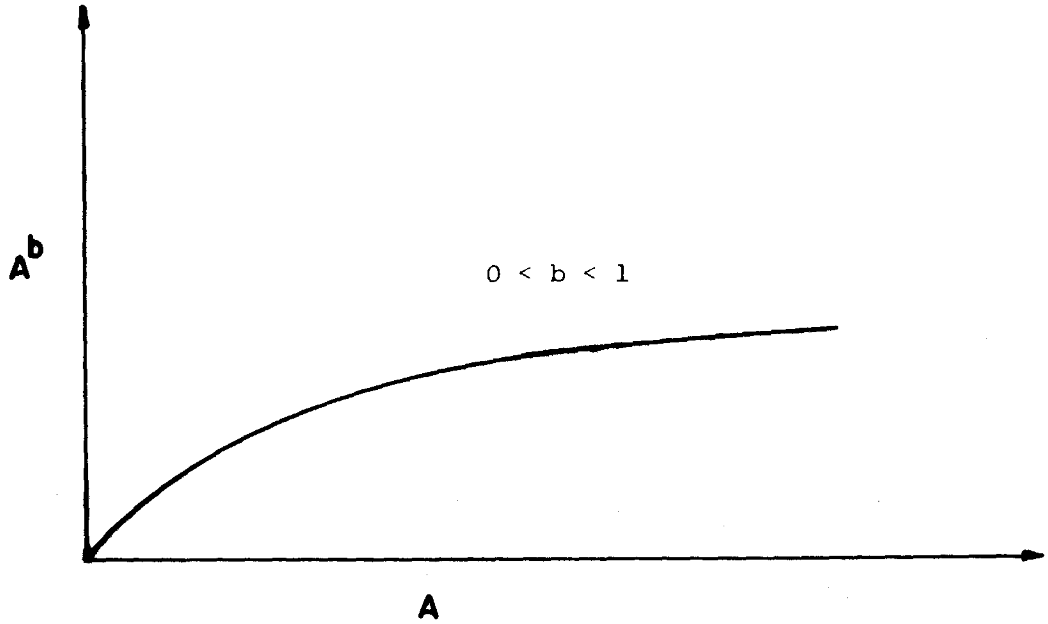


Fig. 2 — Shape of A^b Curve

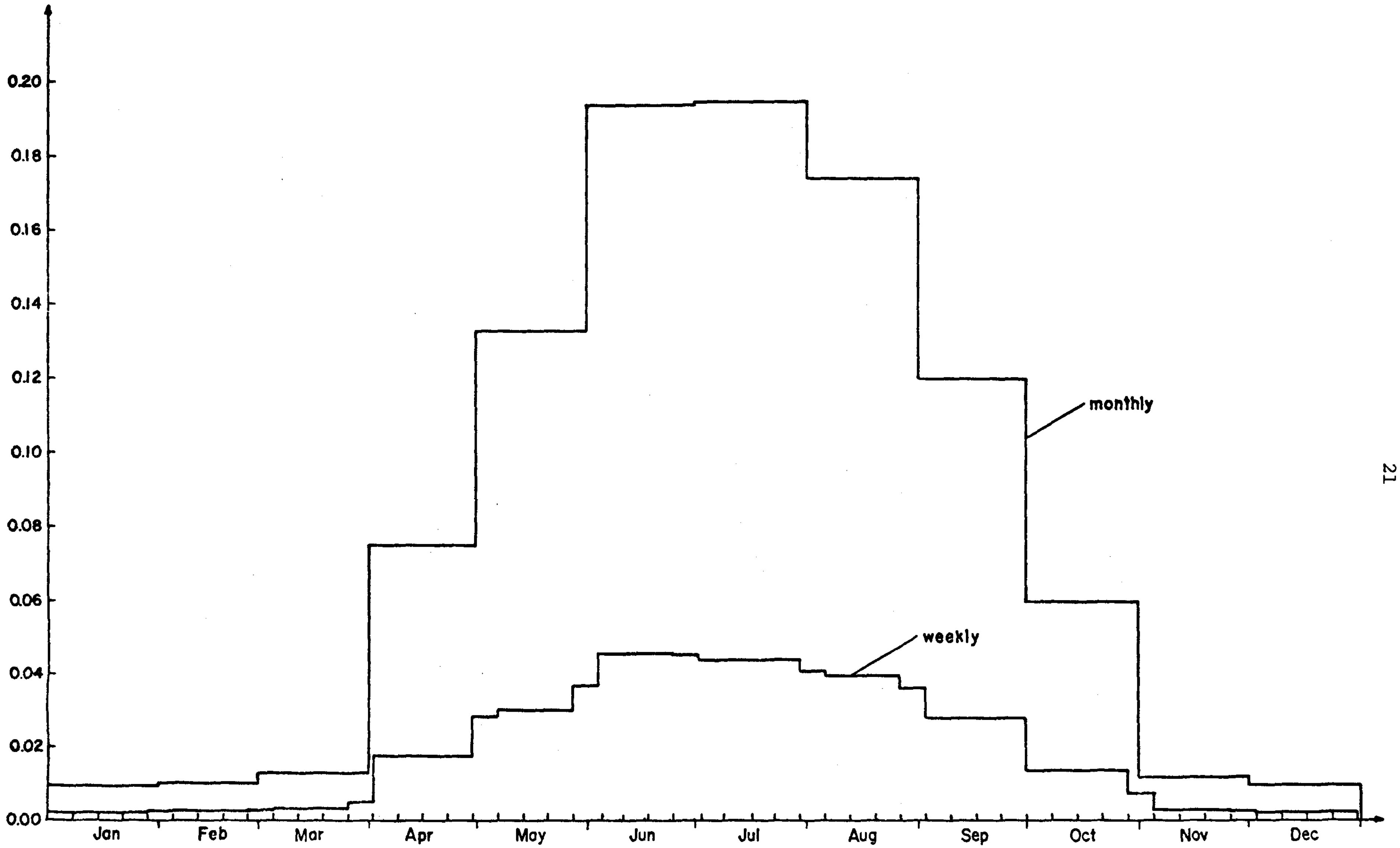


Fig. 3 Monthly & weekly distribution of the annual visits

Figure 3 and Table 9. Thus

$$V \alpha S \qquad (13)$$

where S = weekly fraction of annual visit rate as given in Figure 3 and Table 9.

Combining the relations of Eqs. 11, 12, and 13 and including a term to reflect weather variation effects on recreational use, the proposed recreational value function becomes:

$$v = a\ A^{0.20}\ S\ f(W) \qquad (14)$$

where W = the number of "nice" weather days in the week; and f(W) = functional effect of weather on the recreational use. Again, plagued by the problem of no weekly data on recreational use, the form for f(W) is presented intuitively here. A "nice" weather day is rather arbitrarily defined herein as a day where precipitation lasts less than 3 hours. Obviously, much of the influence of daily weather on recreational use is not represented in this simple approach, but more complex approaches hardly seem worthwhile in the absence of data. Perhaps a better variable to be included as a weather index is mean air temperature at the site. It appears that air temperature may influence user's decisions on visiting the recreation area, particularly during the heavier use periods of the summer. At least, this variable would influence use by those near the area. It is not included here in the development of the recreational use model since the functional relation between temperature and recreational use cannot be estimated from the existing data (not enough data for good estimates). It appears then that this variable would be little better than the nice weather days variable defined in terms of rainfold hours. Subsequent studies should consider mean air temperature when adequate data becomes available. The effect of the weather on visitation rate is included herein by assuming that the visits predicted by $V = a\,A^b S$ are for perfectly good weather (i.e. F(7) = 1), and that the visits are cut by a factor of 10 for bad weather (i.e. F(0) = 0.1). A power relation is proposed herein; thus the functional form of the equation (including boundary conditions) is

$$f(W) = \frac{0.9}{7^d} W^d + 0.1 \tag{15}$$

If a reduction in the number of good days of weather in the week would reduce the recreational use by less than a proportionate amount, d would be smaller than unity and Eq. 15 would look something like Figure 4. On the other hand, if a reduction in the number of good weather days in a week would reduce the recreational use by more than a proportionate amount, d would be larger than unity.

Equation 14 now becomes

$$V = a\,A^{0.20}\,S\left[\frac{0.9}{7^d} W^d + 0.1\right] \tag{16}$$

The estimation of "a" and "d" would of course be ideally estimated from weekly data, but since this is not possible, the available monthly and annual data are utilized. It is expected that "a" would be changing every year, reflecting population growth, etc., but "d" should be the same every year, since recreational use weather dependence is expected to remain the same. Summing Eq. 16 over the weeks of the year, the annual recreation use AV (in number of visitor-days annually) is

$$AV = \sum_{i=1}^{52} V_i = a \sum_{i=1}^{52} A_i^{0.20} S_i \left[\frac{0.9}{7^d} W_i^d + 0.1\right] \tag{17}$$

For each year, the data of Table 1 in the appendix was used along with the weekly values of A and W listed in Table 10 (which were derived from data supplied by the Army Corps of Engineers at Rock Island).

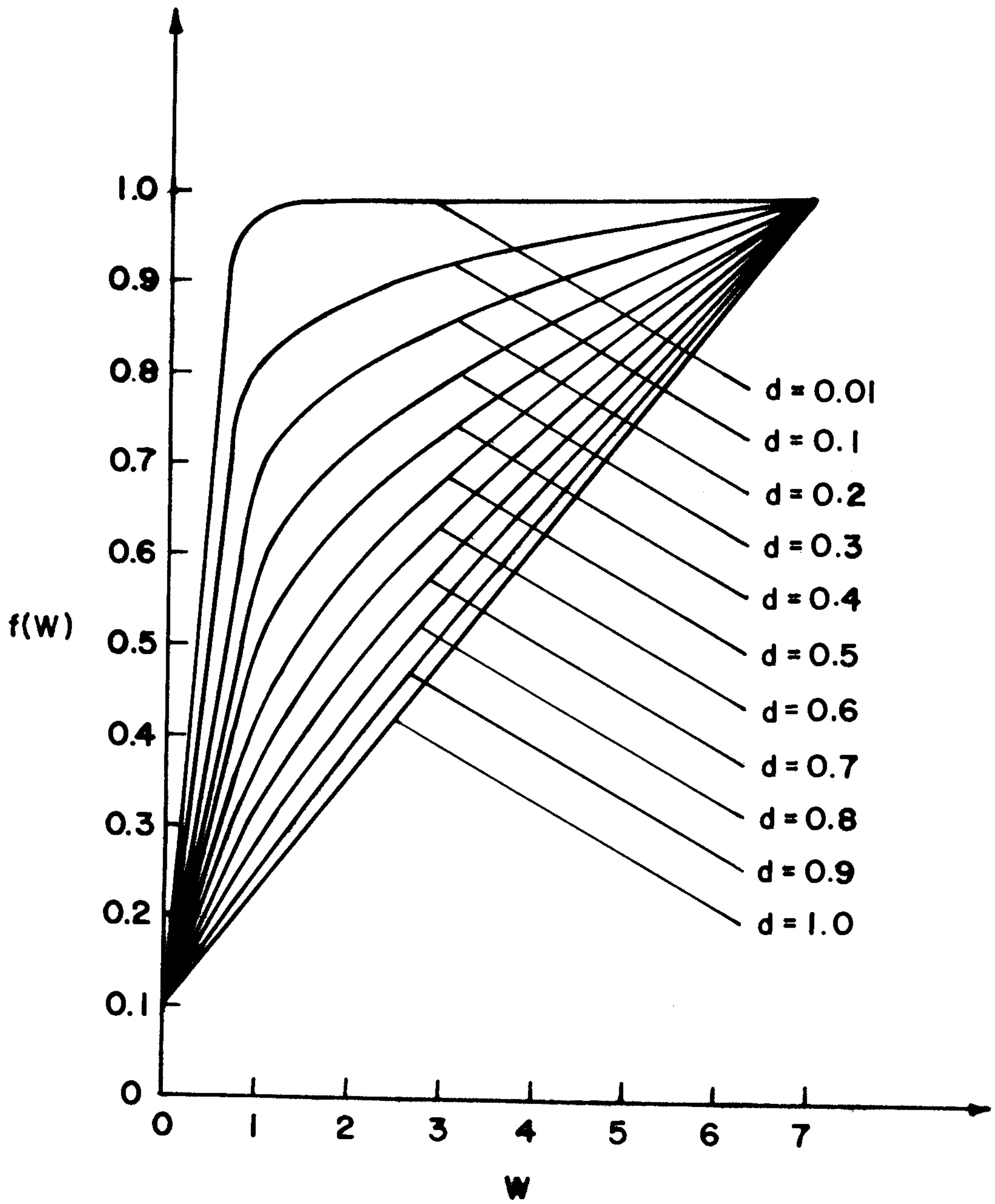


Fig. 4 — Weather effect on recreation visits as a function of the number of good weather days in a week

Thus for each year, an infinite number of solutions may be obtained (a,d) and are plotted in Figure 5. Since the total annual visitor-days is assumed proportional to a, where a is believed to be related mostly to population growth, then AV/a must be constant for each year. The values of "a" and "d" may selected then by finding the smallest sample variance of AV/a for the data of 1967 through 1974. Computer analysis indicates that d = 0.37 results in the smallest sample variance. A comparison of the normalized "a" values for 1964 through 1974 (using d = 0.37, and normalizing with respect to the 1967 "a" value) and the lagged normalized Johnson County population figures (Table 11) for 1967 through 1974 (normalized with respect to the 1967 population) is shown in Figure 6 and Table 12. From inspection of Figure 6, the trend of "a" and the Johnson county population appear somewhat related. As mentioned before, the majority of visitors for Coralville reservoir reside in the two nearby urban areas, Iowa City and Cedar Rapids. Therefore, population trends of Linn County (Fig. 7 and Table 13) and both Linn and Johnson Counties (Fig. 8 and Table 14) were also examined. Comparing these three figures, the Johnson County population trend appears most consistent with the "a" coefficient trend. From this observation, the Johnson County population is adopted herein as a causal factor reflecting the "a" coefficient trends. The assumption of keeping "a" constant within the year but varying it from year to year appears reasonable. Thus, Eq. 16 becomes

$$V = a\, A^{0.20} S\left(0.9\frac{W^{0.37}}{7^{0.37}} + 0.1\right) \qquad (18)$$

where a is given in Table 12 or estimated from Figure 6 and Johnson County population forecasts and S is given in Table 9 or Figure 3. Equation 18 is suggested for estimating the effects on recreational use as affected by operation of the reservoir.

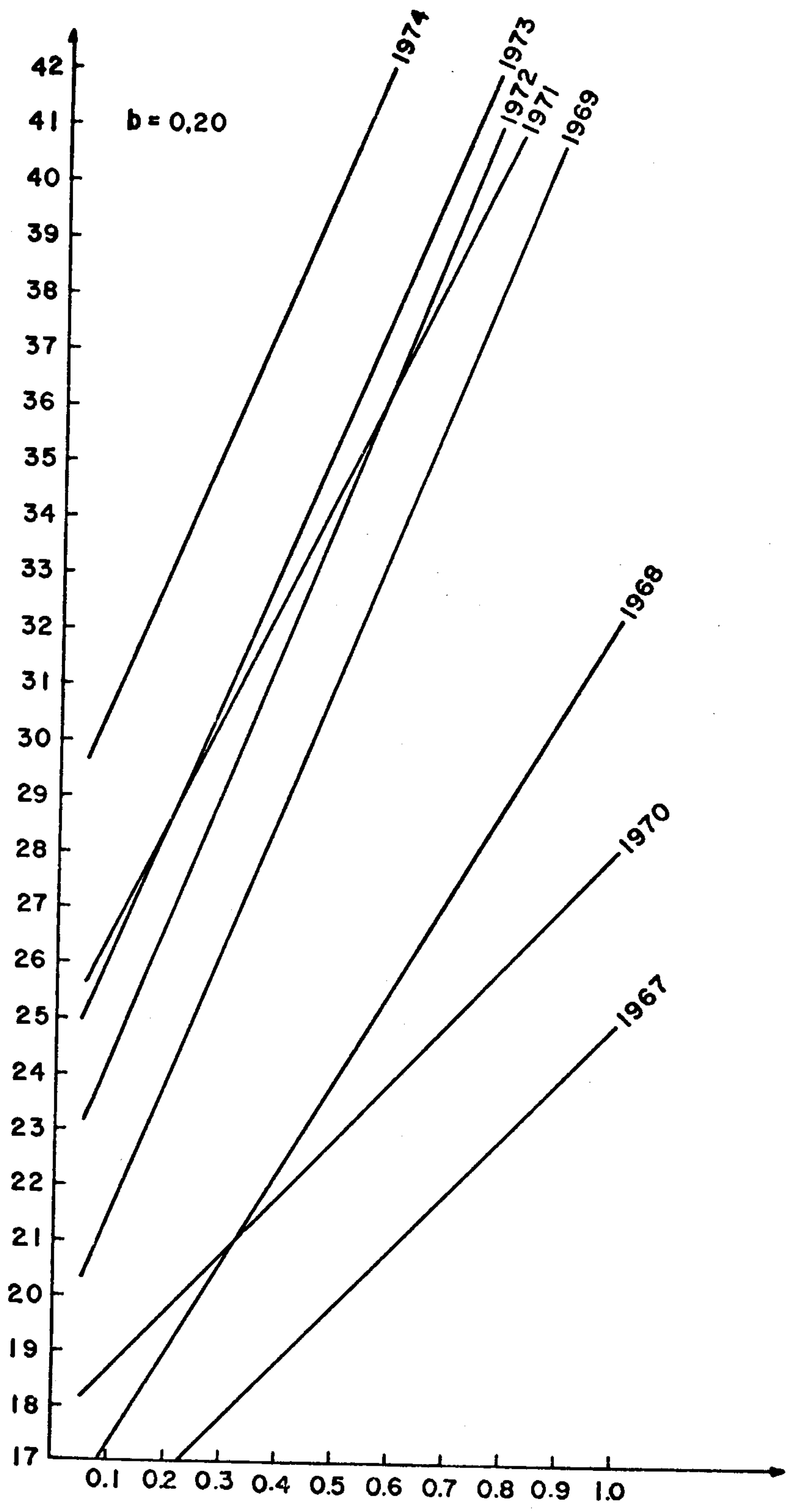


Fig. 5 Values of "a" and "d" which satisfy Eq. 17 using the data of table I and available operation data

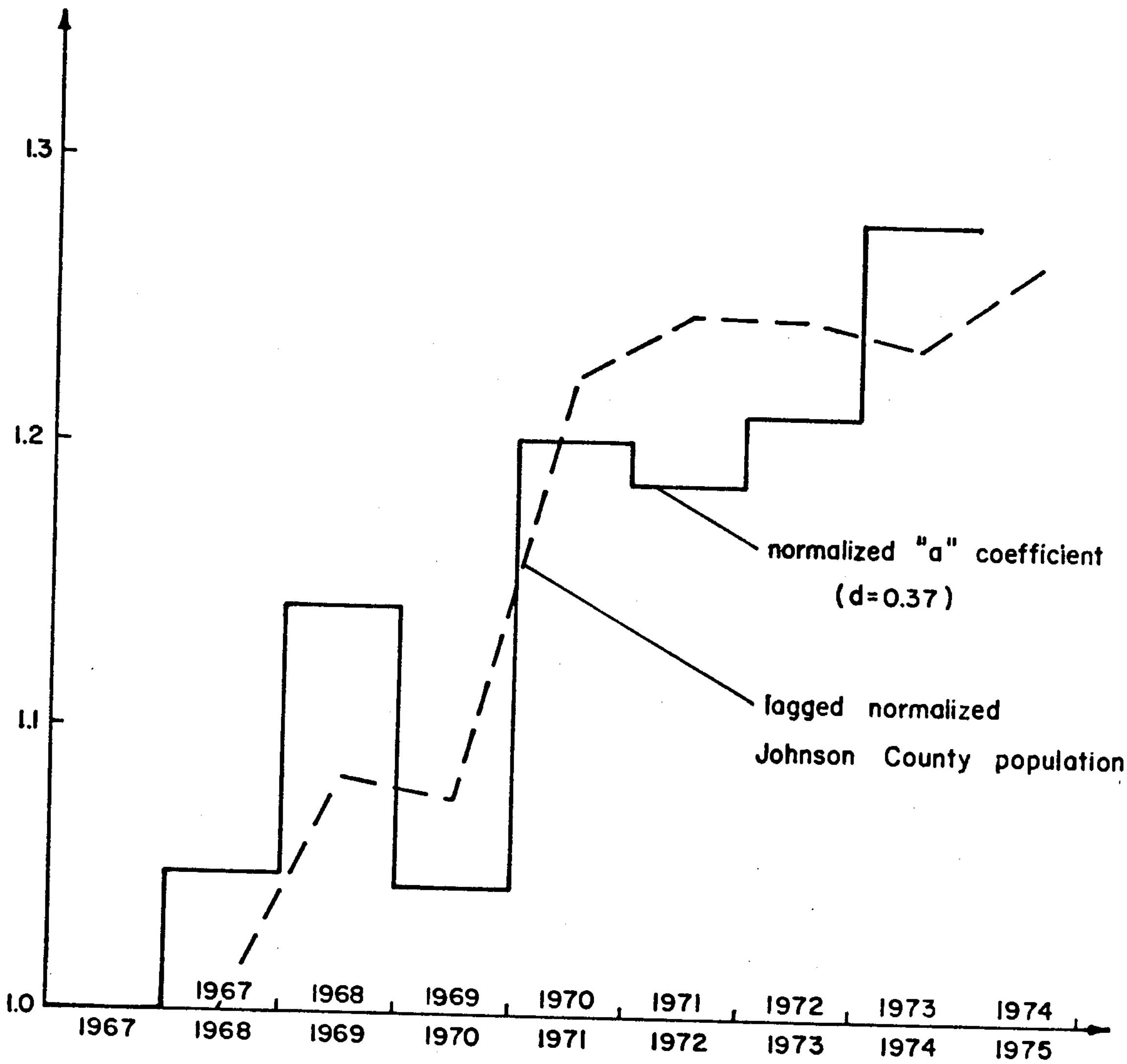


Fig. 6 Comparison plot of population and recreation a coefficient trends

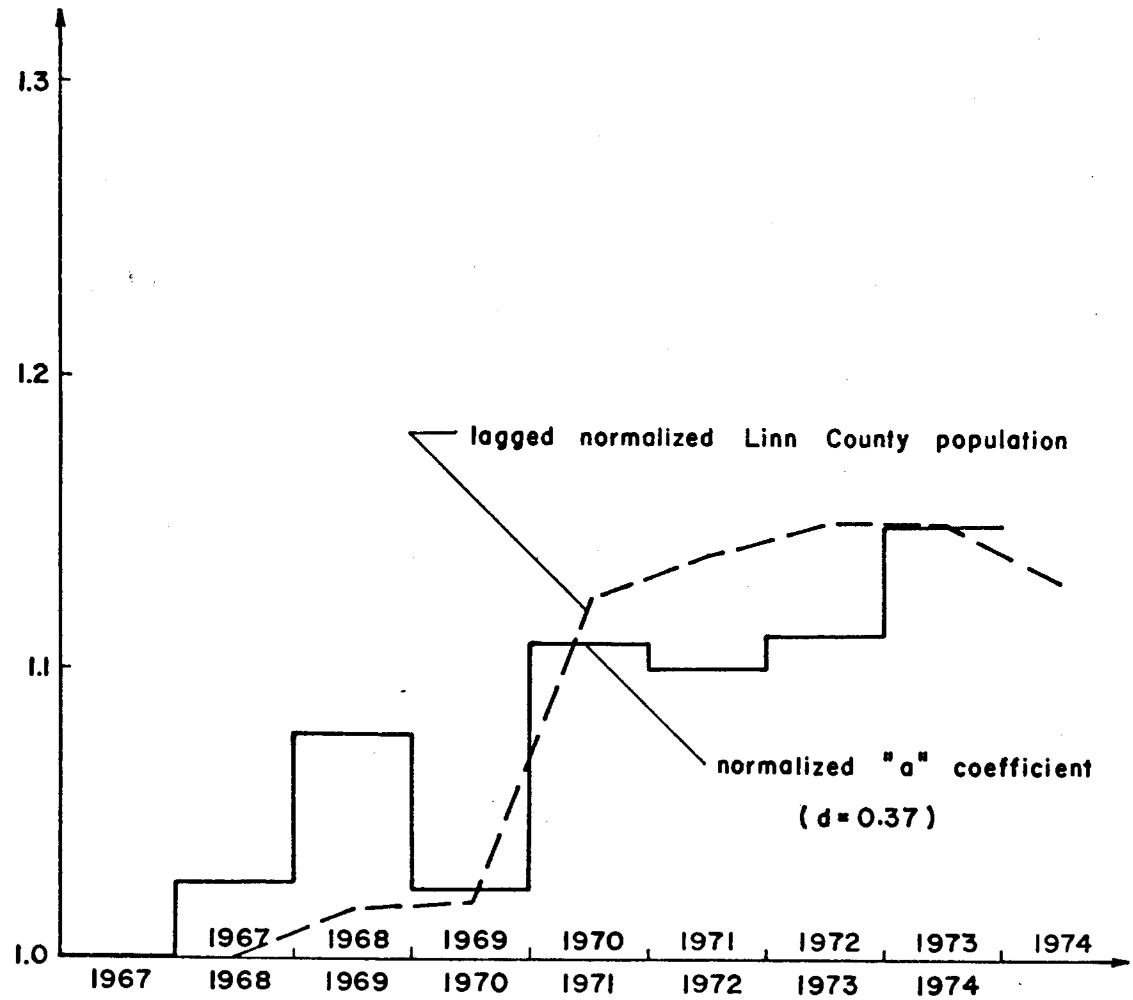


Fig. 7 Comparison plot of population and recreation a coefficient trends

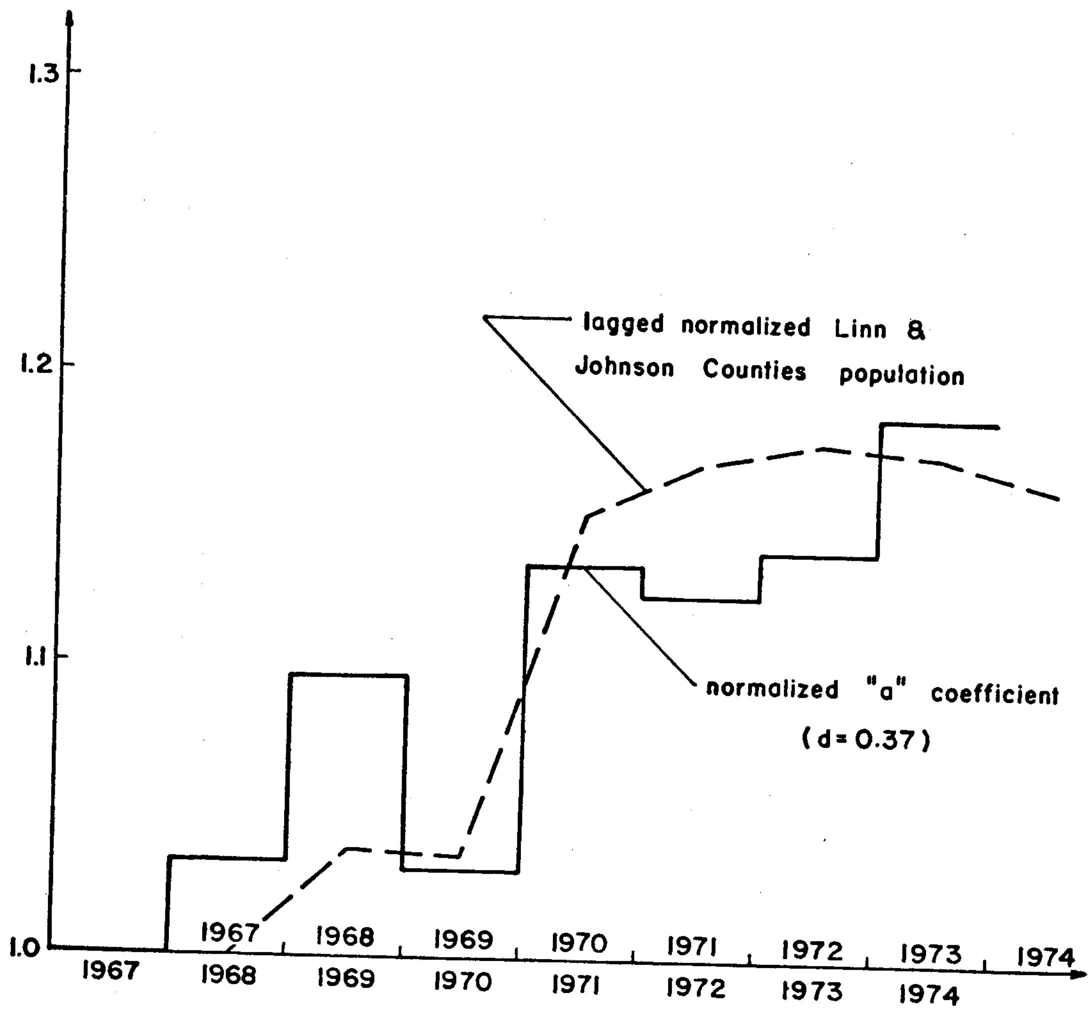


Fig. 8 Comparison plot of population and recreation a coefficient trends

VIII. CONCLUSIONS

Prediction of values in social systems is, at present, more of an art than a science. Awareness of the fact that recreational usage of water resource projects is mounting is a premise to making accurate predictions. Thus, the nature of recreational values associated with water development projects and the methods for their quantitative estimation are reviewed. Currently, available methodologies for estimating reservoir recreational use appear deficient in some respects. However, water resource planning and management must take recreational use into account no matter how difficult and imperfect the prediction may be. In particular, an estimate of recreational use, as affected by reservoir operation decisions on the Coralville reservoir near Iowa City, Iowa, is desired for subsequent use in objective trade-off studies. Therefore, a quantitative measure was derived from available data, which is applicable for determining reservoir operation effects on an index of recreational use for the Coralville reservoir. This measure relates recreational use, expressed in visitor-days to the reservoir, to pool area, weather, seasonal variation, and population of surrounding areas. It is not to be interpreted as a forecast of recreational demand; it is intended primarily to serve as an indicator of operation effects on recreational use. It was derived from data obtained under existing operating rules in which reservoir pool elevation was maintained above minimum limits. Also, the function does not reflect the greater loss resulting from downward pool fluctuations as compared to upward pool fluctuations. Successive studies which utilize the value function derived herein should also make explicit consideration of minimum pool and pool fluctuations during the recreation season.

REFERENCES

1. CAMPBELL, Gene E. and DAWSON, Jeffrey O. 1973 Recreation use projections for the proposed Ames Reservoir and Alternatives. *Ames Reservoir Environmental Study*. Appendix 3, outdoor recreation and open space, chapter 2. Ames, Iowa: Iowa State Water Resources Research Institute.

2. CESARIO, Frank J. 1969 Operations research in outdoor recreation. *J. Leisure Res.* 1 (1), 33-51.

3. CHEUNG, H. K. 1972 A day-use park visitation model. *J. Leisure res.* 4 (2), 139-156.

4. CICCHETTI, Charles J., SENECA, Joseph J. and DAVIDSON, Paul 1969 *The Demand and Supply of Outdoor Recreation.* New Brunswick, N. J.: Rutgers Univ. Bur. Econ. Res.

5. CLAWSON, Marion 1959 Methods of measuring the demand for and value of outdoor recreation. *Resource for the Future, Inc. Repr.* 10, Washington, D. C.

6. CLAWSON, Marion, and KNETSCH, Jack L. 1966 *Economics of Outdoor Recreation.* Baltimore: Johns Hopkins Press.

7. CLAWSON, Marion, HELD, R. B. and STODDAR, C. H. 1960 *Resources for the Future*. Baltimore: Johns Hopkins Press.

8. CRAFTS, Edward D. 1962 Leisure and outdoor recreation. In *Issues in Outdoor Recreation*, pp.13-14, 1972. Burgess Publishing Company.

9. DOUGLASS, James L. 1970 Economic optimization and reservoir recreation. *J. Leisure Res.* 2 (1), 16-19.

10. ELLIS, J. B. and VAN, D. S. 1966 A comparative evaluation of gravity and system theory models for statewide recreational traffic flows. *J. Regional Science.* 6 (2).

11. GAUMNITZ, J. E., SWINTH, R. L. and TOLLEFSON, J. O. 1973 Simulation of water recreation users' decision. *Land Economics.* 49 (3), 269-277.

12. GARDNER, James S. and HULTQUIST, Nancy B. 1973 Recretaion use and users of the Coralville-MacBridge area: a comparative case study. *Ames Reservoir Environmental Study.* Appendix 3, outdoor recreation and open space, chapter 5. Ames, Iowa: Iowa State Water Resources Research Institute.

13. GARDNER, James S. and HULTQUIST, Nancy B. 1973 *The Human Ecological Impact of Structural Flood Control on the Iowa River, Iowa.* Iowa City: The University of Iowa.

14. GRUBB, H. W. and GOODWIN, J. T. 1968 Economic evaluation of water in the preliminary Texas water plan. *Tex. Water Develop. Board Repr.* 84, Austin, Texas.

15. HOLMAN, Mary A. and BENNETT, James T. 1973 eterminants of use of water-based recreational facilities. *Water Resources Research.* 9 (6), 1208-1218.

16. HOTELLING, H. 1947 Letter to director of the United States National Park Service. In *ORRRC Study Rep.* 24, 1962, Washington, D. C.

17. KNETSCH, Jack L. 1964 Economics of including recreation as a purpose of Eastern water projects. *J. Farm Economics.*

18. KNETSCH, Jack L. 1969 Assessing the demand for outdoor recreation. *J. Leisure Res.* 1 (1), 85-87.

19. KNETSCH, Jack L. 1963 Outdoor recreation demands and benefits. *Land Economics.* 39 (4), 387-396.

20. KNETSCH, Jack L. 1974 Outdoor recreation and water resources planning. *Water Resources Monograph Series,* No. 3. American Geophysical Union.

21. McCUEN, Richard H. 1973 A sequential decision approach in recreational analysis. *Water Resources Bulletin.* 9 (2), 219-230.

22. MEREWITZ, L. 1966 Recreational benefits of water resource development. *Water Resources Research.* 2 (4), 625-640.

23. MILLIKEN, J. G. and MEW, H. E. Recreation impact of reclamation reservoirs. A summary of the report *Economic and Social Impact of Recreation at Reclamation Reservoirs.* Bureau of Reclamation.

24. MOELLER, G. H. and ECHELBERGER, H. E. 1974 Approaches to forecasting recreation consumption. *USDA Forest Service General Technical Report* NC-9.

25. PETERSON, George L. and NEWMANN, Edward S. 1969 Modeling and predicting human response to the visual recreation environment. *J. Leisure Res.* 1 (3), 219-237.

26. U. S. ARMY Corps of Engineers 1974 Public records in the office of the Coralville Reservoir manager.

27. RADIN, Alex 1967 Artificial lakes: multi-purpose reservoirs. In *Issues in Outdoor Recreation,* pp. 67-72, 1972. Burgess Publishing Company.

28. SENECA, J. J. 1968 An analysis of Recreational use of the TVA lakes. *Land Economics.* 44, 529-534.

29. SENECA, J. J. and CICCHETTI, C. J. 1969 User response in outdoor recreation: a production analysis. *J. Leisure Res.* 1 (3), 238-245.

30. SHAFER, Elwood L., Jr., and THOMPSON, Roger C. 1968 Models that describe use of Adirondack campgrounds. *For. Sci.* 13, 383-391.

31. SIRLES, John E. 1968 Application of marginal economic analysis to reservoir recreation planning. *University of Kentucky Water Resources Institute Publication* No. 12, Lexington, Kentucky.

32. STATE OF IOWA 1972 *State Parks in Review--1972.* Des Moines: Iowa State Conservation Commission.

33. STATE OF IOWA 1968 *Outdoor Recreation in Iowa.* Des Moines: Iowa State Conservation Commission.

34. STATE OF IOWA 1966 *Iowa Outdoor Recreation.* Des Moines: Iowa State Conservation Commission.

35. TRICE, A. H. and WOOD, S. E. 1958 Measuring of recreation benefits. *Land Economics.* 34 (3), 195-207.

36. TUSSEY, Robert C. 1967 Analysis of reservoir recreation benefits. *University of Kentucky Water Resources Institute Publication* No. 2, Lexington, Kentucky.

37. ULLMAN, E. L. and VOLK, D. J. 1962 An operational model for predicting reservoir attendance and benefits: implications of a location approach to later recreation. *Mich. Acad. Sci., Arts and Lett. paper.*

38. U. S. ARMY Corps of Engineers 1975 *Draft Environmental Impact Statement for Coralville Lake and the Downstream Area of Influence to Columbus Junction, Iowa.* Rock Island, Ill.: Corps of Engineers.

Appendix - Available Data for Coralville Recreational Use Estimation

Table la Attendance Records for Coralville Lake

year	activity days	% change from previous year
1963	322,000	———
1964	426,200	+32.4
1965	402,700	- 5.5
1966	769,366	+91.1
1967	735,140	- 4.4
1968	784,100	+ 6.7
1969	1,115,000	+42.2
1970	843,500	-24.3
1971	1,249,300	+48.1
1972	1,264,700	+ 1.2
1973	1,542,800	+22.0
1974	1,719,300	+11.4

Source: Public records in the office of the Coralville Reservoir Manager, U.S. Army Corps of Engineers, Rock Island, Ill., Aug 1975

Table 1b   Attendance Records for Coralville Lake

	1974		1973		1972		1971		ave.
	attend-ance	fraction of each month	attend-ance	fraction of each month	attend-ance	fraction of each month	attend-ance	fraction of each month	monthly dist.
Jan	13300*	0.00774	13800*	0.00894	14000*	0.01107	12000*	0.00961	0.00934
Feb	15300*	0.00890	17300*	0.01121	13000*	0.01028	12000*	0.00961	0.01000
Mar	24400*	0.01419	25800	0.01672	14000*	0.01107	12000*	0.00961	0.01290
Apr	114300	0.06648	109200	0.07078	116600	0.09220	87200	0.06980	0.07482
May	221400	0.12877	214800	0.13923	198800	0.15719	130100	0.10414	0.13233
Jun	343700	0.19991	312500	0.20255	215800	0.17063	252400	0.20203	0.19378
Jul	357400	0.20788	305900	0.19828	235100	0.18589	229500	0.18370	0.19394
Aug	309900	0.18025	258400	0.16749	191000	0.15102	242000	0.19371	0.17312
Sep	195200	0.11353	173900	0.11272	153800	0.12161	160500	0.12847	0.11908
Oct	85200	0.04956	81200	0.05263	79600	0.06294	89600	0.07172	0.05921
Nov	25900*	0.01506	17500*	0.01134	17000*	0.01344	10000*	0.00800	0.01196
Dec	13300*	0.00774	12500*	0.00810	16000*	0.01265	12000*	0.00961	0.00952

*estimated data

Source: Public records in the office of the Coralville Reservoir Manager, U.S. Army Corps of Engineers, Rock Island, Ill., Aug 1975.

Table 2 Duration and Frequency of Use

(data expressed at % of N)	Total N=223	West Overlook N=62	Sugar Bottom N=58	Sandy Beach N=27	Macbride Primitive N=29	Macbride Modern N=47
Time Traveling						
Less than 30 mins.	36.2	50.0	31.6	48.1	17.2	28.3
30 - 1 hour	38.5	25.8	54.4	37.0	44.8	32.6
Up to 5 hours	21.3	14.5	14.0	11.1	37.9	34.8
Up to 1 day	2.3	3.2	0.0	3.7	0.0	4.3
More than 1 day	1.8	6.5	0.0	0.0	0.0	0.0
Frequency						
1-2 times per week	18.9	29.5	24.1	37.0	0.0	0.0
3-4 times per week	4.1	1.6	3.4	14.8	0.0	4.3
Over 4 times/week	0.9	1.6	1.7	0.0	0.0	0.0
1-2 times/month	14.4	16.4	19.0	7.4	17.2	8.5
3-4 times/month	9.0	3.3	20.7	7.4	3.4	6.4
1-2 times/year	11.3	4.9	8.6	3.7	17.2	23.4
3-4 times/year	13.5	14.8	8.6	25.9	17.2	8.5
1st or 2nd time here	27.0	24.6	13.8	3.7	44.8	48.9
Type of Vacation						
Major vacation	10.0	9.8	12.5	7.4	6.9	10.6
Short vacation	25.5	26.2	32.1	22.2	20.7	21.3
Weekend or overnight	47.7	45.9	39.3	51.9	72.4	42.6
One day only	7.3	3.3	12.5	7.4	0.0	10.6
Stop enroute	4.1	4.9	1.8	0.0	0.0	10.6
½ day or less	5.5	9.8	1.8	11.1	0.0	4.3

Source: Gardner & Hultquist, Recreation Use and Users of the Coralville -- MacBride Area: A Comparative Case Study, Ames Reservoir Environmental Study, Appendix 3, Outdoor Recreation and Open Space, Chapter 5, 1973.

Table 3 Response to Question: Why Did You Come Here Instead of Some Other Place in the Vicinity?[a]

(data expressed as % of N)

	Total N=170	West Overlook N=54	Sugar Bottom N=39	Sandy Beach N=20	Macbride Primitive N=19	Macbride Modern N=38
beach, swim	6.4	1.6	1.7	3.7	0.0	25.0
boat, ski	6.9	9.8	8.7	11.1	0.0	2.2
clean	7.8	4.9	3.5	11.1	14.2	6.9
close	35.4	44.2	38.5	29.6	21.4	31.8
friends	10.5	16.3	8.7	7.4	17.8	2.2
inexpensive	11.5	16.3	21.0	3.7	0.0	0.0
like it	17.0	13.1	19.2	22.2	17.8	15.9
showers	1.8	0.0	0.0	0.0	0.0	9.0

(a) Each respondent could mention as many as three reasons.

Source: Gardner & Hultquist, Recreation Use and Users of the Coralville -- MacBride Area: A Comparative Case Study, Ames Reservoir Environmental Study, Appendix 3, Outdoor Recreation and Open Space, Chapter 5, 1973.

Table 4 Activities of Participation by Respondents[a]

(data expressed as % of N)	TOTAL[b] N=217	West Overlook N=61	Sugar Bottom N=57	Sandy Beach N=27	Macbride Primitive N=28	Macbride Modern N=44
bicycling	.9	1.6	0.0	3.7	0.0	0.0
boat	26.5	26.2	31.5	59.2	10.7	13.6
canoe	9.0	9.8	10.5	14.8	10.7	11.3
camping						
tent	12.1	18.0	8.7	3.7	10.7	15.9
trailer	18.0	21.3	31.5	0.0	0.0	15.9
motorhome	13.0	11.4	17.5	22.2	0.0	0.0
driving, sightseeing	3.6	3.2	5.2	0.0	3.5	4.5
fishing	37.3	34.4	22.8	40.7	75.0	38.6
games	9.4	8.1	17.5	0.0	14.2	2.2
hiking	10.8	13.1	3.5	0.0	0.0	31.8
horseback	2.9	1.6	0.0	0.0	0.0	2.2
picnicking	7.2	3.2	7.0	7.4	10.7	11.3
relax	32.4	42.6	35.0	0.0	42.8	22.7
sailing	1.3	1.6	0.0	0.0	0.0	4.5
sunbathe	.4	0.0	1.7	0.0	0.0	0.0
swim	50.4	39.3	56.1	48.1	42.8	70.4

(a) Each respondent could mention as many as three activities.

(b) In this and in successive tables, if the N is less than the total sample it refers to the number of persons answering the question.

Source: Gardner & Hultquist, Recreation Use and Users of the Coralville -- MacBride Area: A Comparative Case Study, Ames Reservoir Environmental Study, Appendix 3, Outdoor Recreation and Open Space, Chapter 5, 1973.

Table 5 Response to Question: What is Attractive About this Place?

(data expressed as % of N)

	% of Total N=217	West Overlook N=61	Sugar Bottom N=57	Sandy Beach N=27	Macbride Primitive N=28	Macbride Modern N=44
boating	18.4	24.5	17.5	37.0	3.5	9.0
close to home	14.7	18.0	17.5	11.1	7.1	13.6
cost (free)	9.6	13.1	19.2	7.4	0.0	0.0
facilities	38.7	22.9	33.3	51.8	57.1	47.7
fishing	17.0	19.6	10.5	11.1	35.7	13.6
scenery	10.5	21.3	5.2	11.1	3.5	6.8
swimming	27.6	34.4	28.0	18.5	3.5	38.6
trees	11.5	6.5	5.2	22.2	14.2	18.1
uncrowded	17.9	13.1	28.0	11.1	28.5	9.0
water-related (combining fishing, boating, swimming)	63.0	78.5	56.0	66.6	42.7	61.2

(a) Each respondent could mention as many as three items.

Source: Gardner & Hultquist, Recreation Use and Users of the Coralville -- MacBride Area: A Comparative Case Study, Ames Reservoir Environmental Study, Appendix 3, Outdoor Recreation and Open Space, Chapter 5, 1973.

Table 6 Response to Question: When Searching for a Recreation Area, What Do You Look For?

(data expressed as % of N)

	Total N=153	West Overlook N=48	Sugar Bottom N=26	Sandy Beach N=13	Macbride Primitive N=26	Macbride Modern N=40
boating	9.5	8.3	23.0	0.0	0.0	0.0
camping	30.4	14.5	19.2	23.0	19.2	30.0
cost	1.9	2.0	0.0	7.6	0.0	0.0
facilities	34.2	41.6	57.6	7.6	19.2	47.5
fishing	6.6	4.1	0.0	0.0	11.5	5.0
grass	5.7	8.3	0.0	7.6	0.0	2.5
quiet	4.7	6.2	3.8	0.0	3.8	0.0
trees	27.6	14.5	11.5	46.1	23.0	17.5
swimming	5.7	0.0	0.0	0.0	0.0	15.0
uncrowded	18.0	8.3	7.6	30.7	26.9	5.0
view	7.6	8.3	8.8	7.6	7.6	12.5
water	89.5	75.0	61.5	53.8	65.3	50.0

(a) Respondent allowed three responses.

Source: Gardner & Hultquist, Recreation Use and Users of the Coralville-MacBride Area: A Comparative Case Study, Ames Reservoir Environmental Study, Appendix 3, Outdoor Recreation and Open Space, Chapter 5, 1973.

Table 7 Response to Question: Why Did You Select This Particular Site?

(data expressed as % of N)

	Total N=202	West Overlook N=60	Sugar Bottom N=55	Sandy Beach N=24	MacBride Primitive N=26	Macbride Modern N=37
available	15.3	15.0	12.7	29.1	11.5	13.5
beach, swim	4.9	8.3	9.0	0.0	0.0	0.0
flat, level	17.3	20.0	9.0	20.8	3.8	24.3
friends, relatives	6.9	6.6	14.5	4.1	3.8	0.0
near water	28.2	33.3	34.5	20.8	23.0	8.1
secluded	20.2	16.6	18.1	16.6	23.0	29.7
trees	23.7	11.6	20.0	37.5	53.8	18.9
view	18.8	18.3	27.2	33.3	7.6	5.4

(a) Respondent allowed three responses.

Source: Gardner & Hultquist, Recreation Use and Users of the Coralville -- MacBride Area: A Comparative Case Study, Ames Reservoir Environmental Study, Appendix 3, Outdoor Recreation and Open Space, Chapter 5, 1973.

Table 8 Importance of Water

(data expressed as % of N)

Question:	Total	West Overlook	Sugar Bottom	Sandy Beach	Macbride Primitive	Macbride Modern
Would you still come here if there were no water?	N=223	N=62	N=58	N=27	N=29	N=47
"yes"	24.2	33.9	24.1	22.3	0.0	27.7
Does the depth many any difference?	N=176	N=46	N=50	N=17	N=25	N=38
"yes"	41.5	39.1	60.0	52.9	28.0	23.7
Does the expanse make any difference?	N=155	N=40	N-39	N=15	N=23	N=38
"yes"	52.9	55.0	51.3	73.3	52.2	44.7
Do you think there are any bad features of the reservoir?	N=61	N=20	N=23	N=7	insufficient response	
"water fluctuation"	29.5	15.0	34.7	71.4		

Source: Gardner & Hultquist, Recreation Use and Users of the Coralville -- MacBride Area: A Comparative Case Study, Ames Reservoir Environmental Study, Appendix 3, Outdoor Recreation and Open Space, Chapter 5, 1973.

Table 9 Weekly Distribution of Visits Under Ideal Conditions for the Coralville Reservoir

week	friction of annual visits	week	friction of annual visits	week	friction of annual visits
1	0.0021	19	0.0299	37	0.0278
2	0.0021	20	0.0299	38	0.0278
3	0.0021	21	0.0299	39	0.0278
4	0.0021	22	0.0366	40	0.0134
5	0.0023	23	0.0452	41	0.0134
6	0.0025	24	0.0452	42	0.0134
7	0.0025	25	0.0452	43	0.0134
8	0.0025	26	0.0450	44	0.0073
9	0.0027	27	0.0438	45	0.0028
10	0.0029	28	0.0438	46	0.0028
11	0.0029	29	0.0438	47	0.0028
12	0.0029	30	0.0438	48	0.0026
13	0.0050	31	0.0404	49	0.0021
14	0.0175	32	0.0391	50	0.0021
15	0.0175	33	0.0391	51	0.0021
16	0.0175	34	0.0391	52	0.0021
17	0.0175	35	0.0359		
18	0.0282	36	0.0278		

derived from monthly distribution (using the data 1971 - 1974) at Coralville Reservoir in Iowa.

Table 10 Water Area (A) and Good Weather Days (W) Values

	1967		1968		1969		1970		1971		1972		1973		1974	
week	A*	W**	A	W	A	W	A	W	A	W	A	W	A	W	A	W
1	5000	3	5050	5	5100	5	5000	5	5000	2	4500	7	8000	5	3900	2
2	4850	6	5000	2	5000	5	5100	7	5050	7	4200	5	8400	6	4150	3
3	4850	4	4950	6	5400	2	4950	5	5000	5	4200	7	7800	4	4400	3
4	4950	2	5000	5	5550	2	4800	4	5000	7	4250	2	10000	3	4500	3
5	4850	4	4800	6	4600	5	4700	5	5000	3	3900	3	6400	5	4400	6
6	4250	6	3500	7	3100	6	4100	6	4600	0	2500	0	6400	5	2250	5
7	2800	3	1600	7	1350	6	1900	7	1600	0	1650	0	2700	3	1900	7
8	1350	5	1450	6	1500	4	1900	6	6600	0	1650	0	1800	5	1900	5
9	1350	6	1450	5	1700	5	3600	2	10700	4	2400	1	2500	5	2050	5
10	1400	7	1550	3	1800	6	7600	5	8100	3	2500	0	3100	1	2750	1
11	1500	4	1450	5	1500	6	3000	5	3400	3	2600	0	6100	1	2200	5
12	1400	4	1450	5	4000	2	1400	3	3700	6	2200	0	13000	3	1750	2
13	1400	3	1350	2	8500	5	1600	4	2000	6	1800	0	15800	1	1800	5
14	1300	4	1500	2	8500	2	1450	5	1500	7	1850	1	15600	2	1800	3
15	1400	1	1650	3	6300	4	1500	2	1450	5	1800	3	12500	4	1850	2
16	1450	3	1650	0	4050	1	1500	2	1500	5	2450	4	18400	1	1800	3
17	1400	5	1400	2	6500	5	1450	5	1700	5	2200	1	23600	3	1750	5
18	1250	4	1300	4	8950	2	1350	6	1450	3	1900	3	22600	2	4100	4
19	1300	2	1500	4	9400	0	1750	3	1600	4	3900	1	21800	3	2800	0
20	1300	4	1600	1	7900	1	6800	5	1700	2	5050	3	20700	6	8200	2
21	1400	6	1500	2	6000	2	10300	3	3800	2	4400	5	18500	1	19400	1
22	1300	6	1450	3	5000	4	10800	0	4900	4	4500	2	19100	3	22200	3
23	2000	3	1400	3	5700	0	10600	7	5000	3	4400	4	20400	4	21300	1
24	5200	1	2000	2	7800	1	9000	0	5150	1	5050	1	20100	1	20800	4
25	6450	0	3300	4	9800	1	7000	2	5000	1	9600	4	19300	4	20600	1
26	5900	3	4500	1	10300	1	5300	5	5000	4	12000	3	18100	3	19300	7
27	5400	7	5000	3	15800	0	5150	4	5100	0	10350	2	16300	3	17200	6
28	4850	4	4950	4	21900	1	5100	5	5500	5	8000	2	13800	5	13500	4
29	5000	5	5150	2	24300	1	5250	3	5200	3	7600	2	10800	4	10000	3
30	5000	4	5150	3	23200	2	5150	4	5150	1	6650	2	6800	1	6900	3
31	5000	3	5100	3	21300	6	5250	2	5100	3	6000	4	4800	6	5500	3
32	5550	3	5250	2	19900	2	6200	3	5100	4	10000	1	4500	1	4900	2
33	5150	4	5050	3	18600	3	5250	4	5100	3	12900	6	4400	5	10300	3
34	5100	2	5050	5	17000	4	5100	5	5100	4	11600	1	4600	3	11800	2
35	5050	4	5050	3	15100	4	5100	6	5100	7	9400	5	4600	3	9400	3
36	5000	7	5050	0	12400	1	5100	0	5300	5	7400	3	4600	2	6850	6
37	5250	3	5050	5	8800	2	5400	1	5350	6	6000	2	4500	1	5900	4
38	5850	4	5050	1	6800	5	6550	0	5400	2	5900	4	4900	3	6000	6
39	6050	4	5250	1	6100	1	6200	3	5400	3	5900	1	5900	1	5850	4
40	6100	3	5400	3	6100	4	6100	5	5400	5	6500	2	5800	2	5850	4
41	6400	1	5700	2	6150	3	6600	5	5400	4	6300	5	5800	4	5900	2
42	6150	5	6200	4	6200	3	6500	6	5500	2	6000	3	5600	7	5900	7
43	6100	2	6200	2	6300	7	6300	1	5550	3	6500	3	5900	5	5850	4
44	6150	1	6100	7	6300	1	6200	1	5700	3	6800	2	5900	4	5850	3
45	6050	6	6150	2	6300	7	6100	4	6200	5	7500	2	5900	7	5850	2
46	6200	4	6250	2	6250	4	6100	3	6300	3	8500	5	6000	5	5800	4
47	6150	7	6250	7	6200	7	6100	4	6400	5	8600	6	6000	2	5800	4
48	6100	5	6100	6	6100	6	6300	4	6400	1	7900	6	6000	4	5800	3
49	6100	3	6050	6	6050	6	6100	7	6200	0	6600	6	5900	3	5800	4
50	5950	4	5700	5	6200	5	5900	1	6300	0	5800	3	5100	2	5550	3
51	5250	1	5550	2	5450	2	5100	5	5350	0	4900	6	4600	4	4000	4
52	5050	3	5200	1	5150	1	4800	7	5150	0	4550	3	4700	3	2500	6

*acres (area)
**good weather days per week

Table 11 Johnson County Population

Year	Population
1953	39714
1954	41881
1955	42902
1956	44089
1957	53866
1958	55090
1959	52815
1960	53861
1961	54450
1962	54900
1963	55500
1964	59150
1965	61800
1966	59150
1967	59310
1968	64250
1969	63800
1970	72607
1971	73985
1972	73900
1973	73300
1974	75025

Table 12 Normalized "a" and "population of Johnson County" Values

year	population	ratio	a** value	ratio	normalized p	normalized a
1967	59310	1	185012.1	1.000	1	1
1968	64250	1.083	217419.7	1.1752	1.083	1.0485
1969	63800	1.076	280917.5	1.5184	1.076	1.1434
1970	72607	1.224	214710.8	1.1605	1.224	1.0444
1971	73985	1.247	320109.8	1.7302	1.247	1.2021
1972	73900	1.246	310185.4	1.6766	1.246	1.1872
1973	73300	1.236	326496.7	1.7647	1.236	1.2116
1974	75025	1.265	371280.2	2.0068	1.265	1.2786
		total area under line = 1.11575		total area under line = 4.0324		

$$\text{*normalized a} = \frac{\text{total area under p ratio line}}{\text{total area under a ratio line}} \times (\text{ordinate} - 1.000) + 1.000$$

**d = 0.37

Table 13 Normalized "a" and "population of Linn County" Values

year	population	ratio	"a" values	ratio	normalized p	normalized a
1967	145720	1.0000	185012.1	1.0000	1.0000	1.0000
1968	148250	1.0174	217419.7	1.1752	1.0174	1.0259
1969	148550	1.0194	280917.5	1.5184	1.0194	1.0766
1970	163800	1.1241	214710.8	1.1605	1.1241	1.0237
1971	165936	1.1387	320109.8	1.7302	1.1387	1.1078
1972	167500	1.1495	310185.4	1.6766	1.1495	1.0999
1973	167400	1.1488	326496.7	1.7647	1.1488	1.1129
1974	164600	1.1296	371280.2	2,0068	1.1296	1.1486
		total area under line = 0.5955		total area under line - 4.0324		

* normalized a = $\frac{\text{total area under p ratio line}}{\text{total area under a ratio line}}$ x (a ordinate - 1.0000) + 1.0000

** a values when d = 0.37

Table 14 Normalized "a" and "population of Johnson & Linn Counties" Values

year	population	ratio	"a" values	ratio	normalized p	normalized a
1964	205030	1.000	185012.1	1.000	1.000	1.000
1968	212500	1.0364	217419.7	1.1752	1.0364	1.0325
1969	212350	1.0357	280917.5	1.5184	1.0357	1.0958
1970	236407	1.1530	214710.8	1.1605	1.1530	1.0297
1971	239921	1.1702	320109.8	1.7302	1.1702	1.1350
1972	241400	1.1774	310185.4	1.6766	1.1774	1.1251
1973	240700	1.1740	326496.7	1.7647	1.1740	1.1414
1974	238500	1.1632	371280.2	2.0068	1.1632	1.1861
		total area under line = 0.7454		total area under line = 4.0324		

$$\text{* normalized a} = \frac{\text{total area under p ratio line}}{\text{total area under a ratio line}} \times (\text{a ordinate} - 1.000) + 1.000$$

** a values when d = 0.37